

Cypraeidae of the Red Sea at Massawa, Ethiopia,
with a Zoogeographical Analysis
based on the SCHILDERS' Regional Lists

BY

T. C. FOIN

Institute of Ecology, Environmental Systems Group, University of California, Davis, Davis, California 95616

AND

L. P. RUEBUSH

Box 67 USA STRATCOM Fac., Asmara, APO New York 09843

(3 Text figures; 1 Table)

BECAUSE OF THE INTERESTS of shell collectors, the genus *Cypraea* has been the subject of an expansive literature, including many lists of species from various faunal provinces. To our knowledge no list of *Cypraea* from the Red Sea since the compilation of SCHILDER & SCHILDER (1938-1939) has been published, however, despite the interesting species that have resulted from the isolation of the Red Sea from the remainder of the Indian Ocean basin. The SCHILDER & SCHILDER records were based on literature records, and many of their recorded species require confirmation. This paper represents several years of collecting by the junior author in the southern Red Sea, and is a compilation of the species found in the area with a comparison to other Indian Ocean species.

The Massawa Area

Massawa, Ethiopia, is located at approximately 39°29' E Latitude and 15°39' N Longitude on the western shore of the Red Sea. The Dahlak Archipelago completely shields Massawa from the open sea to the east, but Massawa is an important port because of the two channels that penetrate the Dahlak Archipelago from the north and the south. The remainder of the area is shallow and generally does not exceed 5 fathoms in depth. *Cypraea* spp. are found in many habitats, ranging from mudflats to coral reefs; some species are accessible intertidally, but most are

obtainable only by diving. Most collections were made in this manner. Collections were made in all seasons; the only notable changes in species abundance occur in the winter months, when it is assumed that many individuals either hide and are inactive, or migrate to deeper water. All measurements were taken with vernier calipers; anatomical studies in this paper are limited to color observations and gross detail of external structures. A map of the collecting area is presented in Figure 1.

Cypraea of the Southern Red Sea

Cypraea annulus LINNAEUS, 1758

This species is very common in the low intertidal and shallow subtidal zones, restricted to areas of old coral and rock rubble possessing strong currents. Shell form is in agreement with that given by ORR (1959) for *Cypraea annulus* from similar habitats off Zanzibar.

Cypraea arabica LINNAEUS, 1758 (*Cypraea grayana* SCHILDER, 1930)

This species is widespread over both the habitat in which *Cypraea annulus* is found and in living coral. Specimens appear to be more abundant in the former habitat. All specimens found have been small for the species, averaging about 30 mm. *Cypraea arabica* is one of the most variable

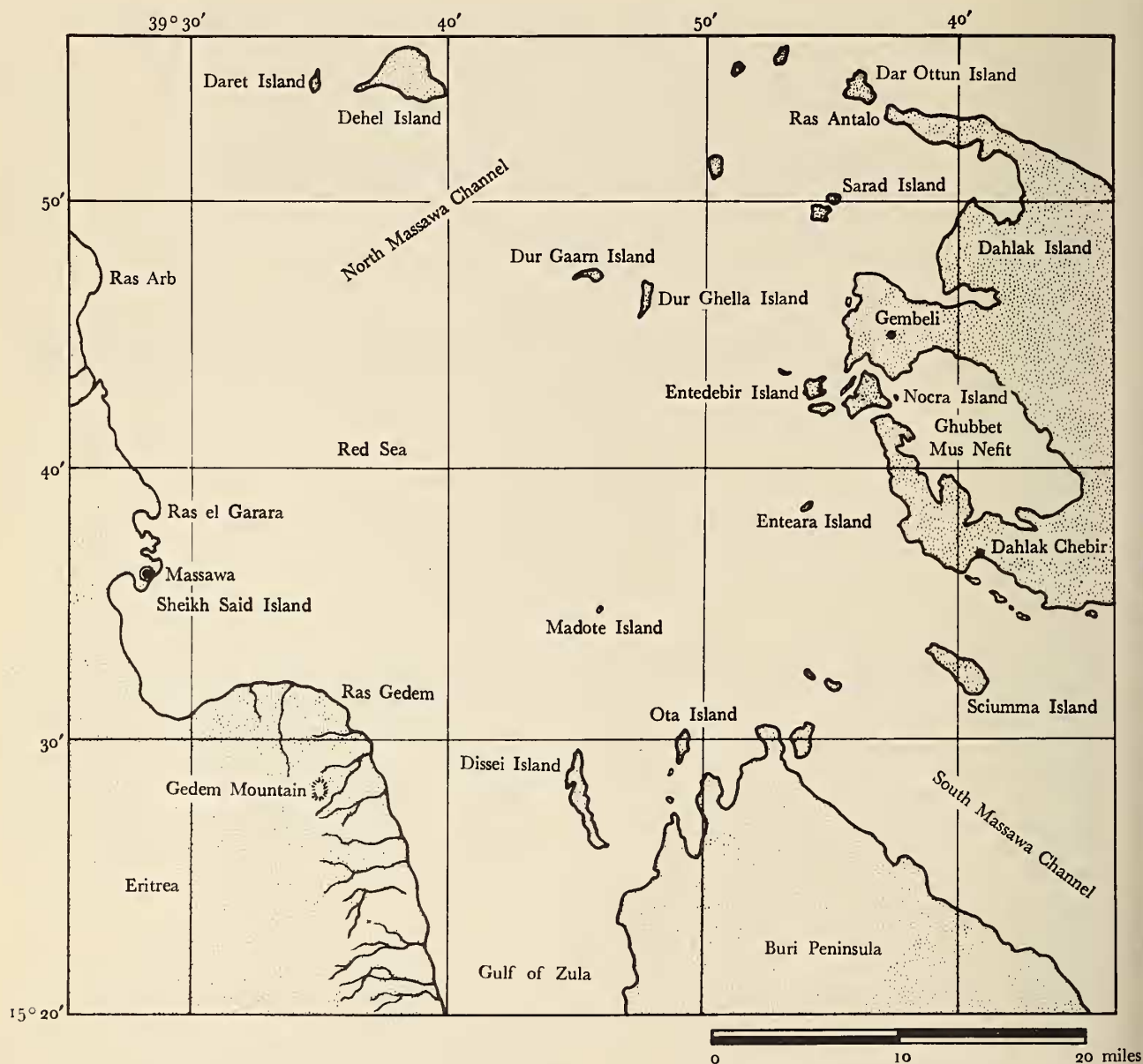


Figure 1
 Map of the Massawa, Ethiopia area, including a part of the
 Dahlak Archipelago
 Adapted from a U. S. Army Map Service chart made in 1936

species found in the Massawa area; specimens may be found that resemble *C. grayana*, *C. eglantina* DUCLOS, 1833, and *C. arabica*. The diagnosis given by SCHILDER & SCHILDER in their prodrome for *C. grayana* emphasizes a subpyriform, often humped shape, reticulate or dilacerate dorsal pattern, and a spire blotch. The SCHILDERS and CERNOHORSKY (1964) diagnose *C. eglantina* as having

a cylindrical shape, unmarginated sides, a spire blotch, and a dorsal pattern of longitudinal lines interrupted by pale lacunae. *Cypraea arabica* is said to differ from these 2 species by the lack of a spire blotch, its hieroglyphic dorsal pattern, ovate shape, and the heavily margined sides. Our analysis of the Massawa "arabica" (Figure 2) of the above characters is based on a classification of each shell

with respect to the base, dorsum, shape, and spire blotch. In the logical tree only the combinations found of the 36 possible are presented. Only one of the sample (N = 19) examined was a *C. grayana* and 3 were *C. arabica*;

Spire	Blotch	Base	Shape	Pattern	No. Specimens			
present	┌	margined	—	subpyriform	—	reticulate	1	
							└	rounded
absent	—	margined	┌	ovate	—	hieroglyphic	3 (= <i>arabica</i>)	
						longitudinal	3	
						reticulate	1	
						cylindrical	hieroglyphic	2
							longitudinal	4
						rounded	cylindrical	—
subpyriform	—	hieroglyphic	2					

Figure 2

Distribution of shell characters of a sample of "*Cypraea arabica*" from Massawa

of the remainder, all but one most closely resembled *C. arabica*. We have, therefore, provisionally called the Massawa specimens *C. arabica* instead of *C. grayana*. This analysis also suggests that a reexamination of the group of species in the "*arabica*" complex may be warranted.

Cypraea camelopardalis PERRY, 1811

Cypraea camelopardalis is relatively common throughout the region on and under coral reefs. This species is the most variable local species in size and pattern; the smallest adults range down to 35 mm, while the largest exceed 70 mm. The dorsum is frequently heavily scarred. Two adult patterns may be distinguished: the normal pattern, with white spots scattered over the dorsum; and individuals ranging from a few white spots to none at all. These differences are assumed to be both genetic and environmental, but since all combinations have been found together, these patterns are thought to bear no taxonomic significance. The color of the external anatomy of *C. camelopardalis* is the same as in *C. vitellus* LINNAEUS, 1758, as described by CERNOHORSKY (1964); this is further evidence of the supposed close relationship of the two species.

Cypraea carneola LINNAEUS, 1758

Cypraea carneola, like *C. annulus*, is restricted to areas of rock and coral rubble swept by strong tides and currents, but may be locally abundant in these places. All species found in these areas have been characterized by small size; *C. carneola* is no exception. Specimens average about 25 mm in size. The dorsum normally is heavily scarred. Conchologically, anatomically, and ecologically, specimens found in the Massawa area closely resemble typical *C. carneola* from the Indo-Pacific.

Cypraea caurica LINNAEUS, 1758

Cypraea caurica may be locally common, although like *C. carneola*, it is restricted to specific habitats. In the Massawa area the species is usually found under isolated coral heads, either living or dead. The species is quite variable in size, in labial denticles, and in the presence or absence of a dorsal blotch, but all specimens are easily recognized as *C. caurica*. The nominal subspecies *C. c. quinquefasciata* BORN, 1778, inhabits the Red Sea. We have not evaluated the validity of this name.

Cypraea clandestina LINNAEUS, 1767

A single living specimen of this species has been found under a rock off Dissei Island, SE of Massawa near the Gulf of Zula. Beach specimens are similarly very rare; we infer that either this species does not normally occur in the Massawa area or is very rare there.

Cypraea erosa nebrites MELVILL, 1888

In the Massawa area individuals of *Cypraea erosa nebrites* are mostly restricted to the islands, largely in areas of isolated living coral and rock rubble, although a few have been found on the mainland at Ras El Garara. *Cypraea e. nebrites* is easily recognized: the marginal blotches are always prominent, do not extend unto the base, the teeth are distant and streaked with red, and the shell is more rounded and compact than Indo-Pacific *C. erosa* LINNAEUS, 1758. The animal also differs in color from Fijian examples: there is a predominance of green in the mantle lobes and siphon. *Cypraea e. nebrites* is relatively common, but Massawa examples are smaller than those from more northerly localities.

Cypraea exusta SOWERBY, 1832

Cypraea exusta is restricted to the NW Indian Ocean and is very rare in the Red Sea. Only 5 specimens have been found, all together, under a coral head in the south

harbor of Massawa. Specimens are easily distinguished from *C. talpa* LINNAEUS by the less expanded base, the more rotund shape, the extremely dark coloration, and the very fine and numerous columellar teeth. It is possible that *C. exusta* is a rare subspecies of *C. talpa*; at least, they are sibling species.

Cypraea felina GMELIN, 1791

Cypraea felina is one of the more common species in the Massawa area; it may be found in rocky habitats, usually in association with *C. annulus*, *C. arabica*, *C. carneola*, and *C. caurica*. This species is not very variable in size or shape. Length-breadth-height measurements comparisons with *C. f. fabula* KIENER, 1843, from the Arabian Gulf and *C. f. felina* of East Africa indicate that the Red Sea subspecies is probably the latter.

Cypraea gracilis notata GILL, 1858

This species is common in the same habitats as *Cypraea felina*. It occurs in two distinct shapes, one more cylindrical, the other pyriform. These forms may be found together, and no ecological significance has been attached to this difference. The colors of the living animal feature a white mantle, orange foot and head, and black eyes. Average lengths of the Massawa individuals range from 13 to 16 mm.

Cypraea isabella LINNAEUS, 1758

Only a single example of *Cypraea isabella* has been found living in the Massawa area (South Harbor). This species does not normally appear to occur in the area.

Cypraea lentiginosa GRAY, 1825

Cypraea lentiginosa is occasionally in the Dahlak Archipelago but very rarely along the mainland. One was found in the South Harbor. It is apparently a recent immigrant to the Red Sea; SCHILDER & SCHILDER (1938-1939) list its center of distribution as the waters between the Gulf of Oman and the Indian subcontinent.

Cypraea lynx LINNAEUS, 1758

This species is occasionally found in the offshore islands but rarely along the mainland. It occurs in the same habitats in which *Cypraea camelopardalis* and *C. pantherina* LIGHTFOOT, 1786, are found. The species is said to be represented in the Red Sea by the subspecies *C. l. williamsi* MELVILL, 1888. The SCHILDERS give a diagnosis for *C. l. williamsi*; they cite a short anterior terminal ridge, blunt posterior extremities, rounded sides, obsolete basal carinae, wide aperture, and a pink base. Base color cannot be

used as a subspecies criterion in this case, as *C. lynx* with pink bases may be found haphazardly over the Pacific and Indian Ocean basins, in all the other nominal subspecies. Individuals of *C. lynx* from various localities in the Indo-Pacific also show the characteristics of *C. l. williamsi*; we feel that *C. l. williamsi* is not a valid subspecies, but this conclusion needs confirmation.

Cypraea pantherina LIGHTFOOT, 1786

Cypraea pantherina is one of the most common and conspicuous cowries of the Red Sea. It is widespread over the region but is restricted to areas of coral development. This species exhibits considerable variation in dorsum coloration, from nearly pure white with few spots, to nearly all black. There are also stages of development of a golden color form, which at its most extreme stage appears as a solid golden brown (*funeralis* SULLIOTTI, 1924). In many specimens the golden nacre is succeeded by a pattern of black spots over white; the golden color persists as the dorsal line. If this is also true for the darkest specimens, the color may persist for less than the lifespan of an individual. A large series of *C. pantherina* demonstrates the intergradation in color that occurs; under these circumstances the name *funeralis* is no more than the name of a specific color form, one which may last for less than the adult life of an individual. Accordingly, it is probably inappropriate that even the informal taxon *forma* should be used for *funeralis*, and the name should be dropped.

Cypraea pulchra GRAY, 1824

This species is found in coral in the Massawa area. The individuals encountered are easily recognizable, as there is almost no variation shown by the species, other than in size.

Cypraea staphylaea LINNAEUS, 1758

A few beach specimens of this Indo-Pacific species have been found, but no living examples are known from Massawa.

Cypraea stolidia erythraeensis SOWERBY, 1837

Cypraea stolidia erythraeensis is restricted to coral reefs on the offshore islands, although it occasionally occurs on the mainland. This subspecies is considerably smaller than the other subspecies of *C. stolidia*; it averages only about 18 mm in length. Specimens are characterized by a plain white base with teeth produced and a large, often isolated, dorsal blotch. *Cypraea s. erythraeensis* appears to be quite invariable except for the form and dimensions of the dorsal blotch. Tooth color is also said to be variable (R. H.

Summers, personal communication). The SCHILDERS accord specific status to *C. s. erythraeensis*.

Cypraea turdus LAMARCK, 1810

Cypraea turdus is frequently found in company with other species inhabiting areas of isolated rock and coral and possessing strong tidal surges and currents. There is considerable size variation, although all specimens seen have been quite broad. An occasional specimen will be nearly all white as the result of very extensive lateral callouses. This species appears to be the most widespread and common of the Massawa Cypraeidae.

The SCHILDERS' list includes several species that have not been found in the Massawa area. These are *Cypraea cicercula* LINNAEUS, 1758, *C. macandrewi* SOWERBY, 1870, *C. nucleus* LINNAEUS, 1758, *C. helvola* LINNAEUS, 1758, *C. teuleri* CAZENAVETTE, 1846, *C. talpa* LINNAEUS, 1758, *C. mappa* LINNAEUS, 1758, and *C. mauritiana* LINNAEUS, 1758. Of these, the SCHILDERS expressed doubt about validity of the *C. talpa* and *C. mauritiana* records; because these are large and normally common species, we are inclined to agree. We also do not believe that *C. moneta* occurs in the Massawa area. Some recent collections of *C. nucleus*, *C. macandrewi*, *C. cicercula*, and *C. gangranosa* have been reported from the Red Sea (R. H. Summers, personal communication). We infer that all these species are rarely collected in the Massawa area. We have no information concerning *C. mappa*, *C. helvola*, or *C. teuleri*, although we have received one unconfirmed report on the former species.

Zoogeographical Implications of the Red Sea *Cypraea*

The British Navy Intelligence Division (1946) has summarized the geological history of the Red Sea basin. The Red Sea is a shallow, warm-water, marginal sea of the Indian Ocean formed by the flooding of part of the East African rift valley around the Pliocene. Shortly thereafter, the Red Sea and the Gulf of Aden were connected to the Indian Ocean, and the main northward flow through the narrow strait (Bab-el-Mandeb) that marks the mouth of the Red Sea was established. One would expect that the recent origin and isolation of the Red Sea would have marked effects on the cypraeid fauna.

Eighteen species are listed from Massawa in this paper, of which 5 are endemic to the Erythraean region. When the regional lists of SCHILDER & SCHILDER (1938-1939) were analyzed and doubtful taxa removed, the Erythraean province clearly had a greater proportion of endemic

species than any other province of the Indian Ocean (Table 1). We removed doubtful records and lumped all

Table 1

Reduced number of species and proportion of endemic species
in regions of the Indian Ocean

	Number of species	Number endemic
Northern Red Sea	19	8
Central Red Sea	24	9
Southern Red Sea	37	10
Gulf of Aden	42	10
Chagos Archipelago	43	1
Mauritius	49	1
St. Francis Bay to East London	27	6
Zanzibar	40	0

“sympatric subspecies” into a single species for these analyses. Our records generally agree with the SCHILDERS' list, and are evidence of the isolation of the Erythraean region from the remainder of the Indian Ocean. We feel, therefore, that the SCHILDERS' lists are sufficient for zoogeographical analysis. The cypraeid fauna is also depauperate in comparison to the remainder of the Indian Ocean, but the total number of *Cypraea* species is similar to that of the South African region. Isolation has produced several nominal subspecies — *nebrites*, *erythraeensis*, and *notata* — and 3 species — *camelopardalis*, *exusta*, and *pantherina*. These 3 species are easily derived as sibling species from 3 common Indo-Pacific ones. These are *Cypraea vitellus*, *C. talpa*, and *C. tigris*, respectively.

When the reduced number of species in the SCHILDERS' lists for the Erythraean region are plotted against distance of the midpoint of the length of the eastern Erythraean region (Gulf of Aden), Figure 3 results. When plotted as a semilog or log-log function, the points more nearly fall in a straight line, but a distinct inflection remains in the curve. Two explanations are possible: either there are more species in the Red Sea than can be accounted for as a simple function of distance, or the Gulf of Aden is depauperate. The latter explanation is unlikely as the reduced number of species reported (43) compares with the main basin of the Indian Ocean (Table 1). The first report of *Cypraea clandestina*, *C. gangranosa*, and *C. lentiginosa* from Massawa, and the increasing proportion of regionally endemic species in a northward direction through the Red Sea, are evidence that species characteristic of other Indian Ocean provinces are still entering the Red Sea, and that given sufficient time the number



Figure 3

Decreases in number of species as a function of distance from the NW Indian Ocean to the Gulf of Suez, from the SCHILDER & SCHILDER lists

of species in the Red Sea should equilibrate with the rest of the Indian Ocean.

We interpret the inflection in the curve of Figure 3, and the number of new species found at Massawa, to mean that Bab-el-Mandeb is not an effective barrier to species immigrating from the Gulf of Aden into the Red Sea, at least at present. The presence of at least 6 sibling species and subspecies implies that the Red Sea was either formerly more isolated or that immigration of a particular new species into the Red Sea has been sporadic and infrequent. We cannot now differentiate between these.

SUMMARY

- (1) Eighteen species have been found in the Massawa, Ethiopia area of the 27 reported by SCHILDER & SCHILDER (1938-1939) list. Four of the 9 species remaining to be collected are probably present but rare, and 3 are probably erroneous reports.
- (2) The Massawa Cypraeidae contain a high percentage of regionally endemic forms (8 of 18), but 6 of these are easily derived from widespread Indo-Pacific species.
- (3) The number of endemic forms and the number of *Cypraea* species indicate that the Red Sea was at least at one time highly isolated from the remainder of the Indian Ocean.
- (4) Analyses of several nominal subspecies from the Massawa area and of the SCHILDER & SCHILDER lists suggest that gene flow within the Cypraeidae may be widespread.

LITERATURE CITED

- CERNOHORSKY, WALTER OLIVER
1964. The Cypraeidae of Fiji (Mollusca:Gastropoda). *The Veliger* 6 (4): 177 - 201; pls. 21 - 26; 1 Text fig.; 1 map (1 April 1964)
- NAVAL INTELLIGENCE DIVISION, ROYAL NAVY, GREAT BRITAIN
1946. Western Arabia and the Red Sea. *Geograph. Handbook Ser. 527*
- ORR, VIRGINIA
1959. A bionomic shell study of *Monetaria annulus* (Gastropoda: Cypraeidae) from Zanzibar. *Notul. Natur.* 313
- SCHILDER, FRANZ ALFRED
1962. Hybrids between *Cypraea tigris* LINNAEUS, 1758 and *Cypraea pantherina* SOLANDER, 1786. *The Veliger* 5 (2): 83 - 87, 1 diagram. (1 Oct. 1962)
- SCHILDER, FRANZ ALFRED, & MARIA SCHILDER
1938 - 1939. Prodrôme of a monograph on living Cypraeidae. *Proc. Malacol. Soc. London*, 23 (3): 119 - 180; (1939) 23 (4): 181 - 231; 1 text fig.; 9 maps. (15 November 1938 and 15 March, 1939)

